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**Kröni et al.**

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(54) **HEARING DEVICE WITH WAX GUARD INTERFACE**

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(51) **Int. Cl.**
***H04R 25/00*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***H04R 25/654*** (2013.01); ***H04R 25/602*** (2013.01); ***H04R 25/604*** (2013.01); *H04R 2225/025* (2013.01)

(58) **Field of Classification Search**
CPC ..... H04R 2460/17
USPC ..... 381/325
See application file for complete search history.

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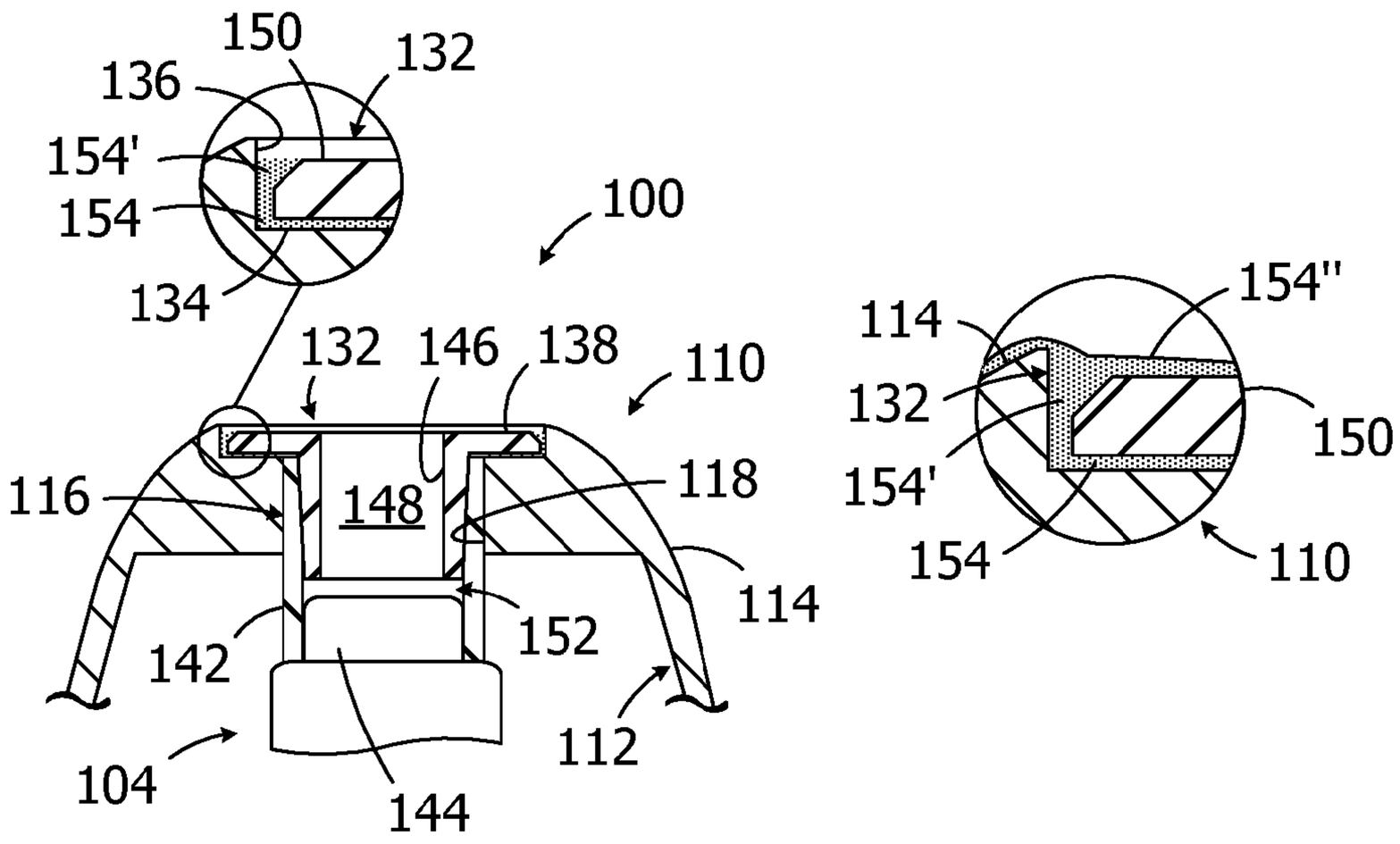
(57) **ABSTRACT**

An apparatus with a hearing device housing including at least one wall with a sound aperture and a counterbore around the sound aperture, and a bushing, having a portion thereof located within the counterbore and secured thereto, configured to receive a hearing device cerumen guard.

**12 Claims, 5 Drawing Sheets**



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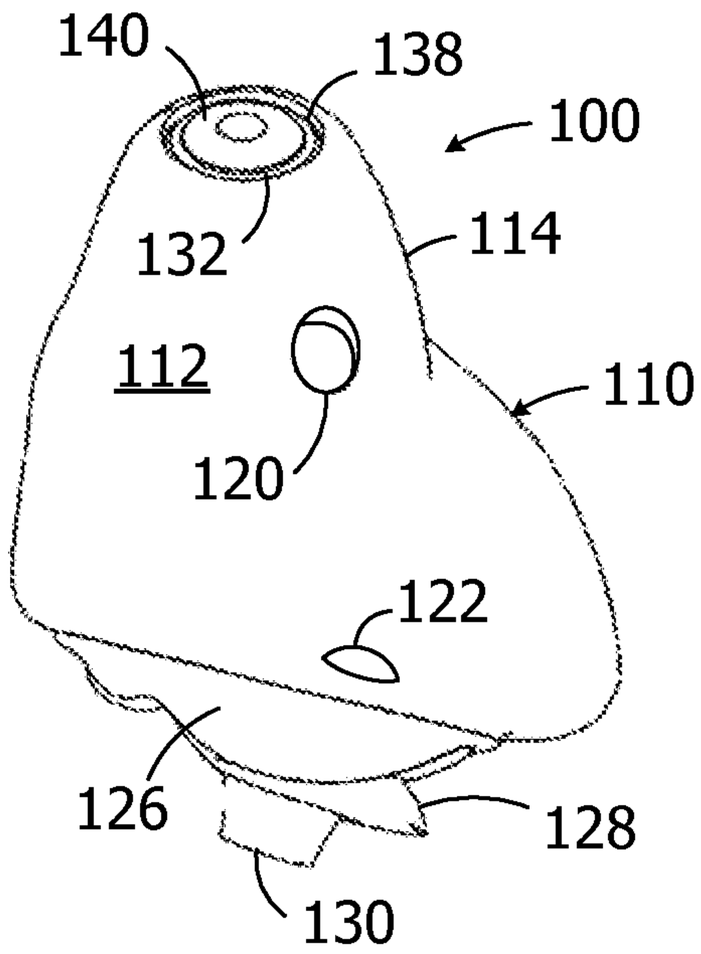


FIG. 1

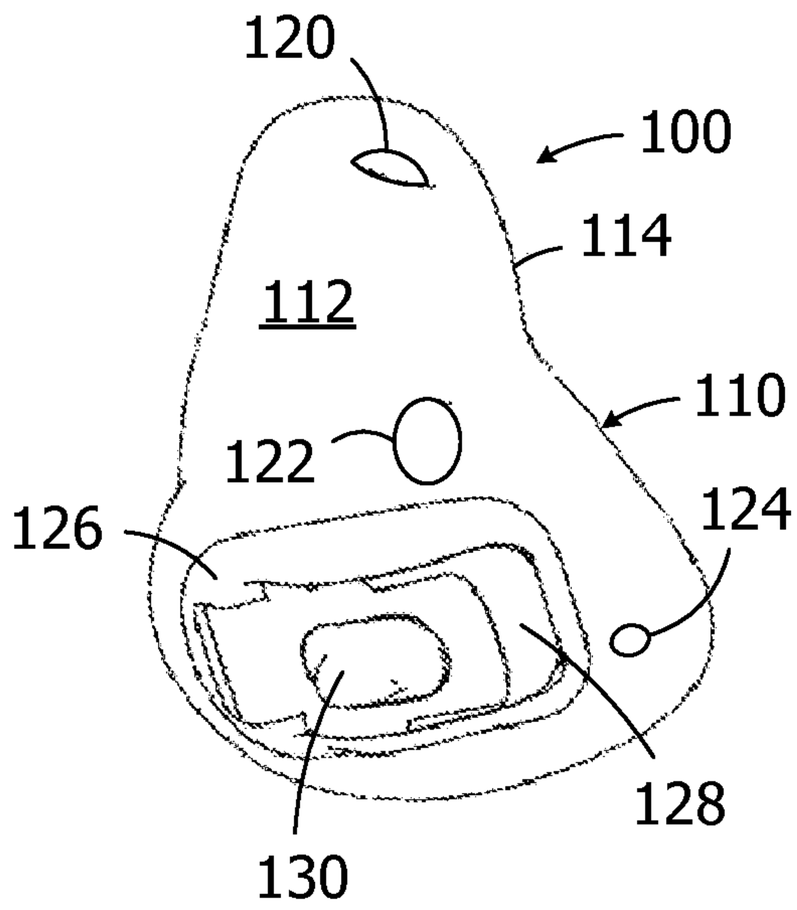


FIG. 2

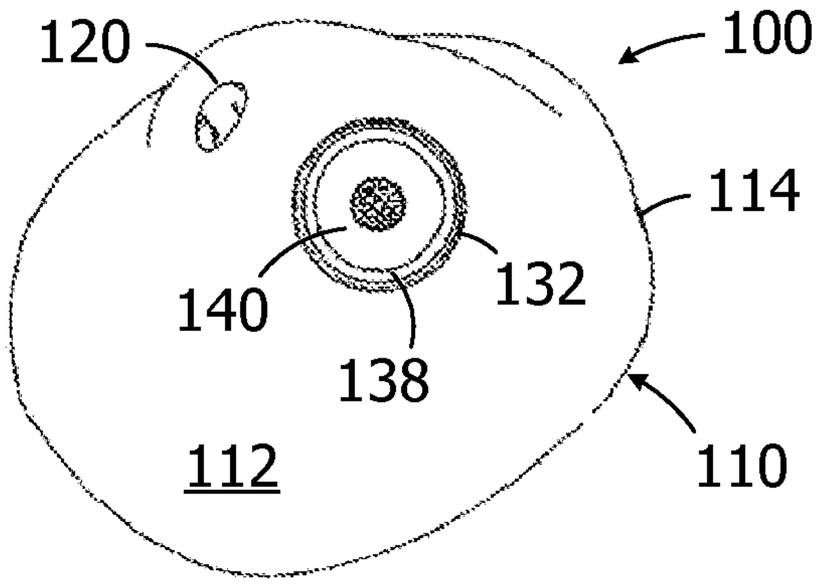


FIG. 3

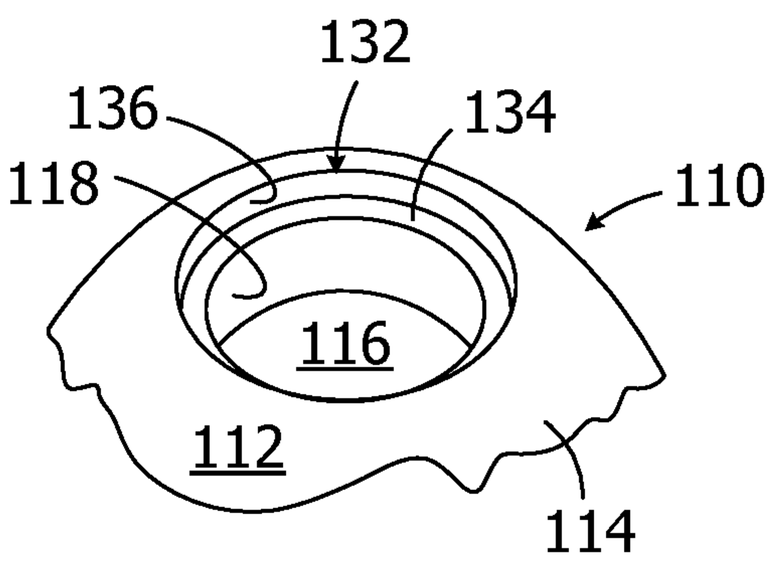


FIG. 4

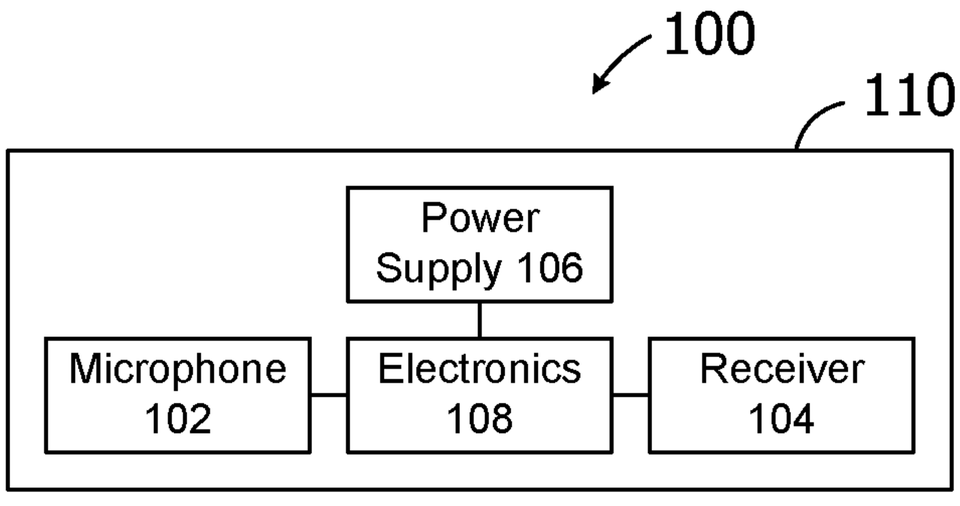


FIG. 5

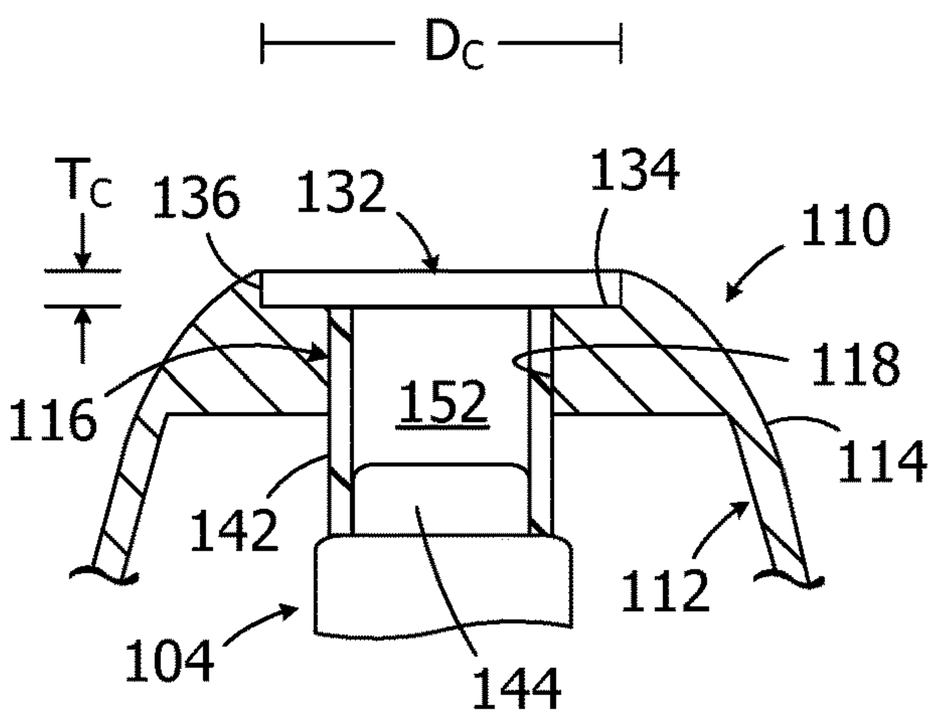


FIG. 6

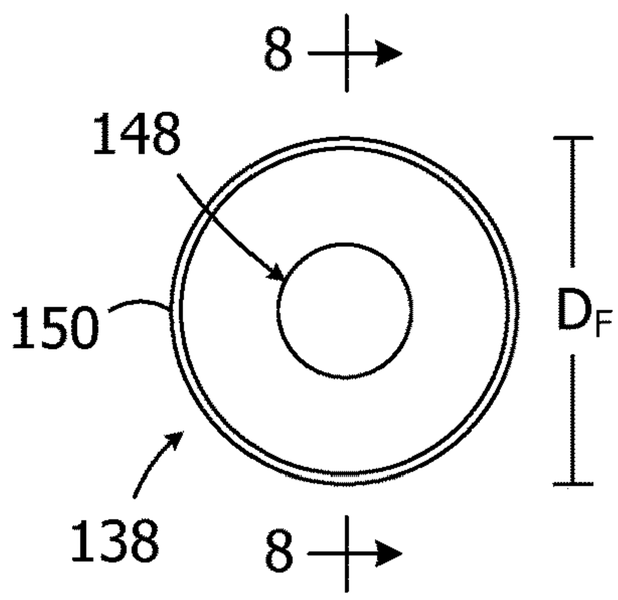


FIG. 7

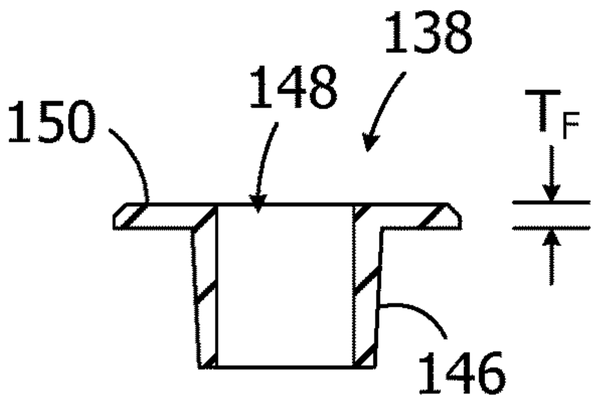


FIG. 8

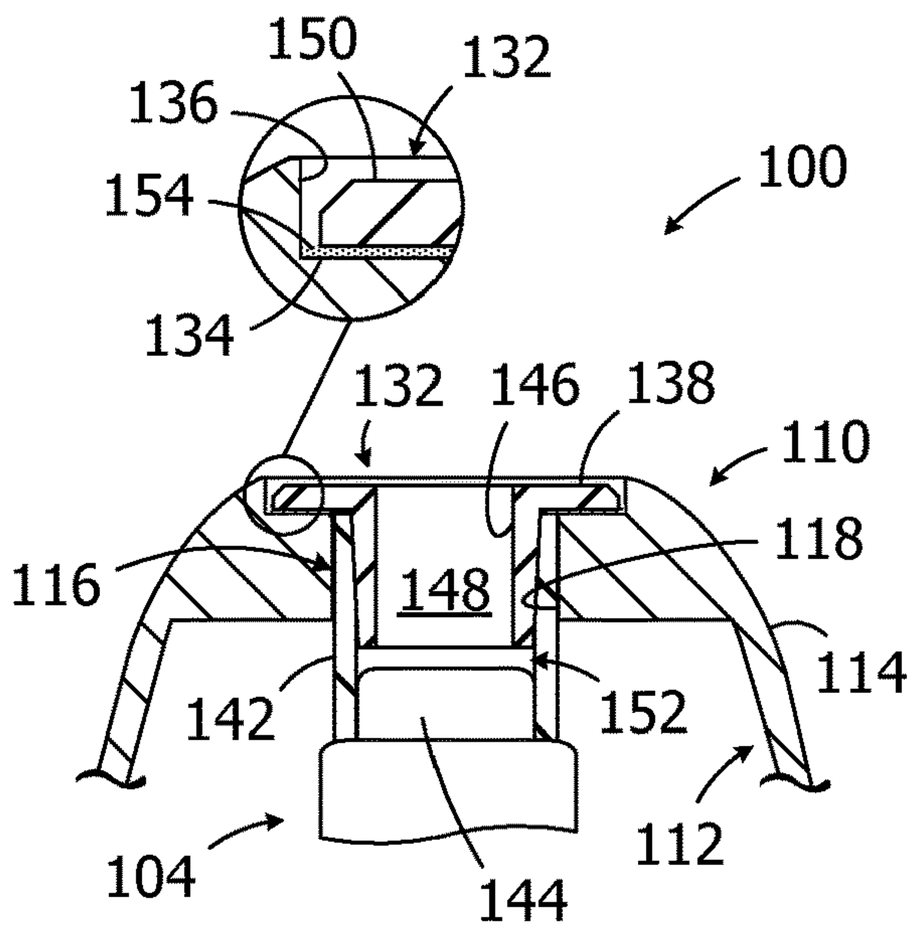


FIG. 9

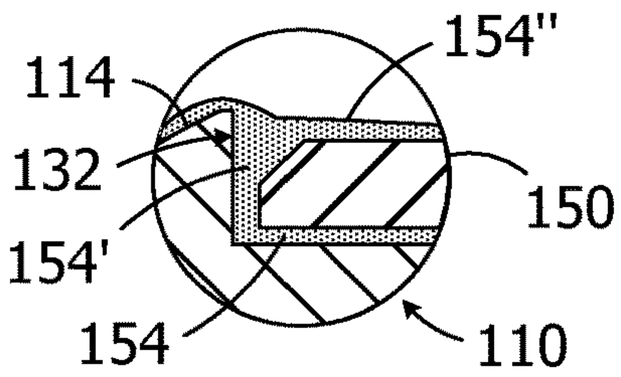


FIG. 10A

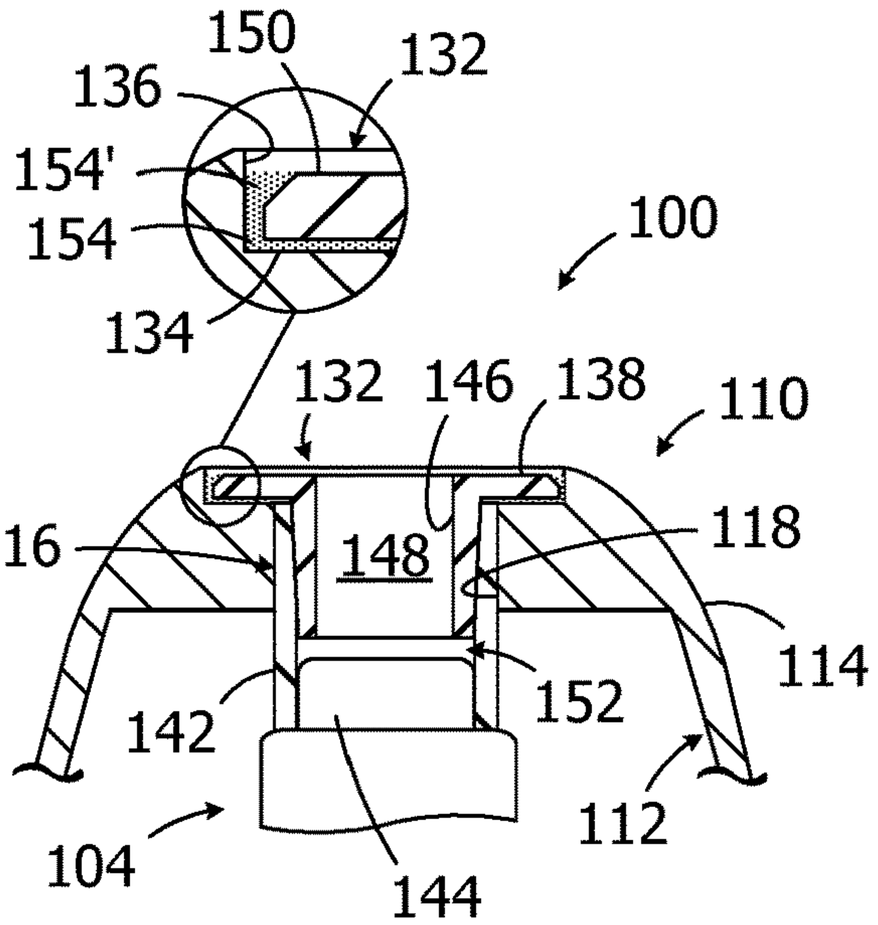


FIG. 10

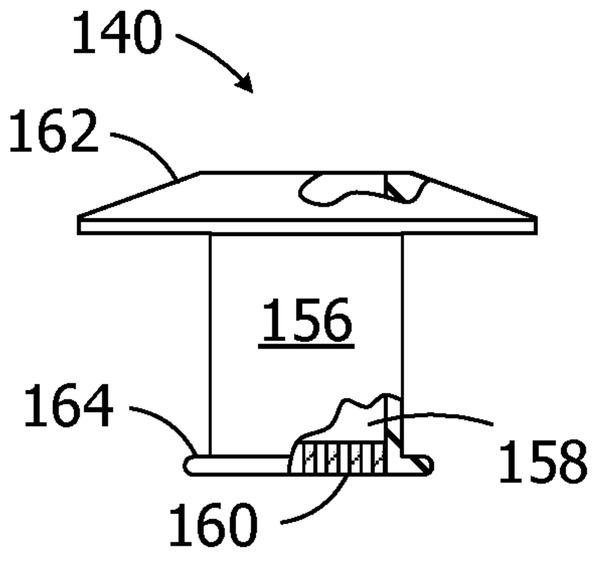


FIG. 11

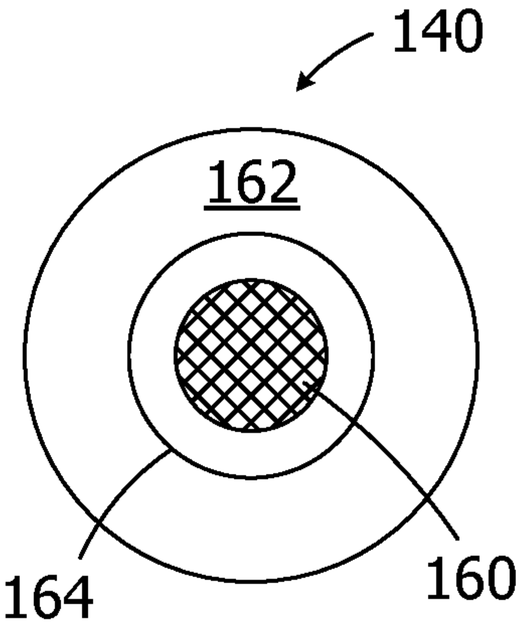


FIG. 12

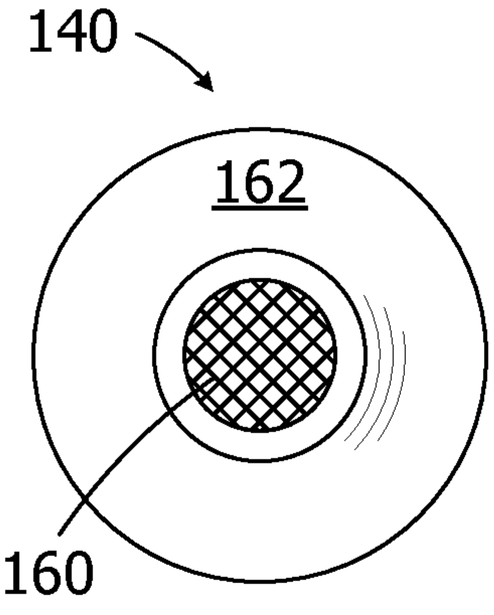


FIG. 13

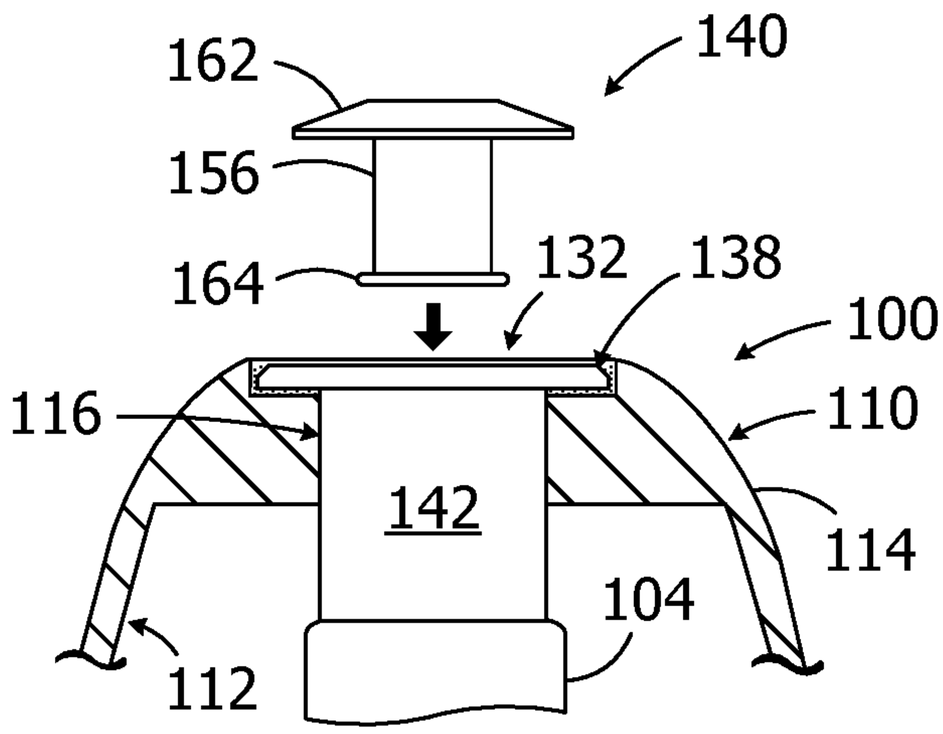


FIG. 14

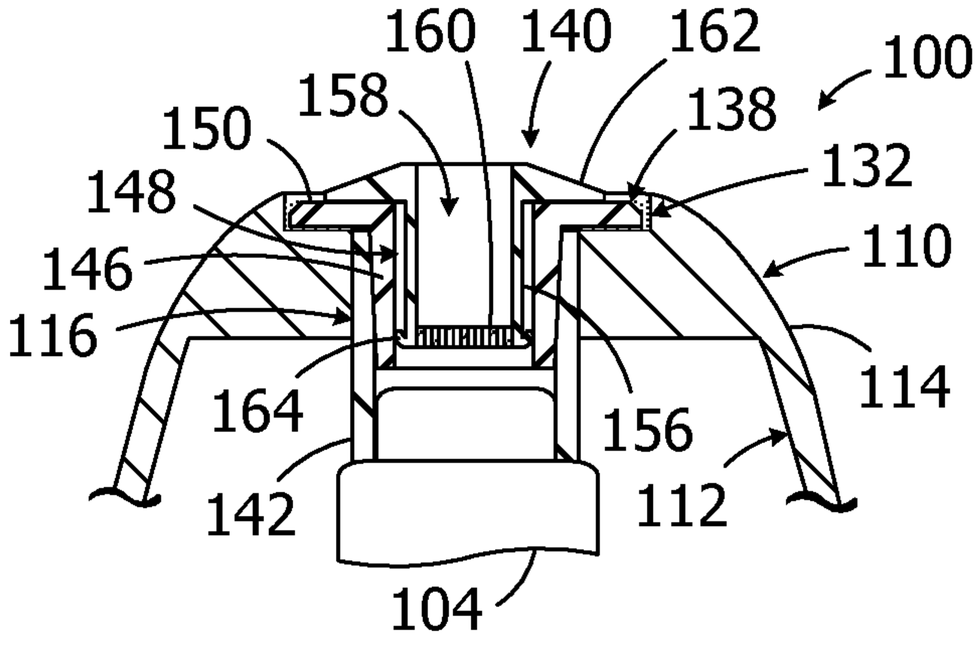


FIG. 15

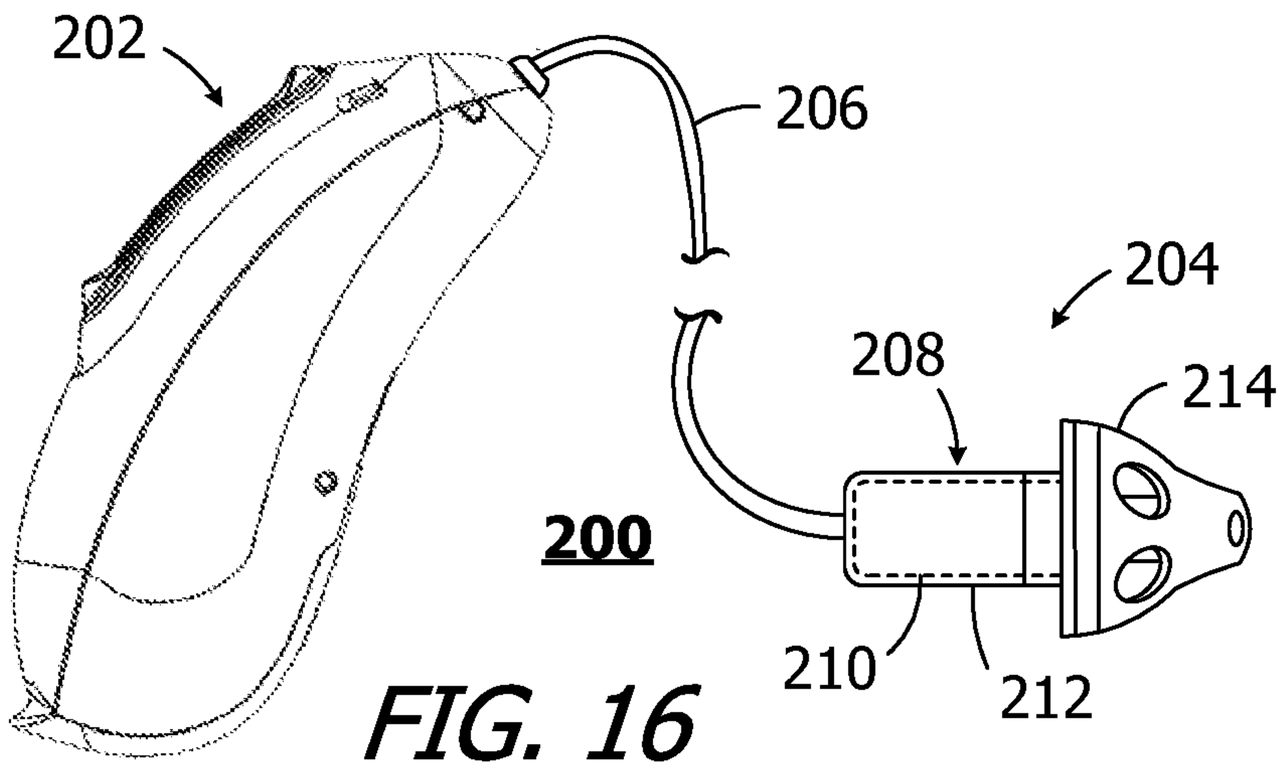


FIG. 16

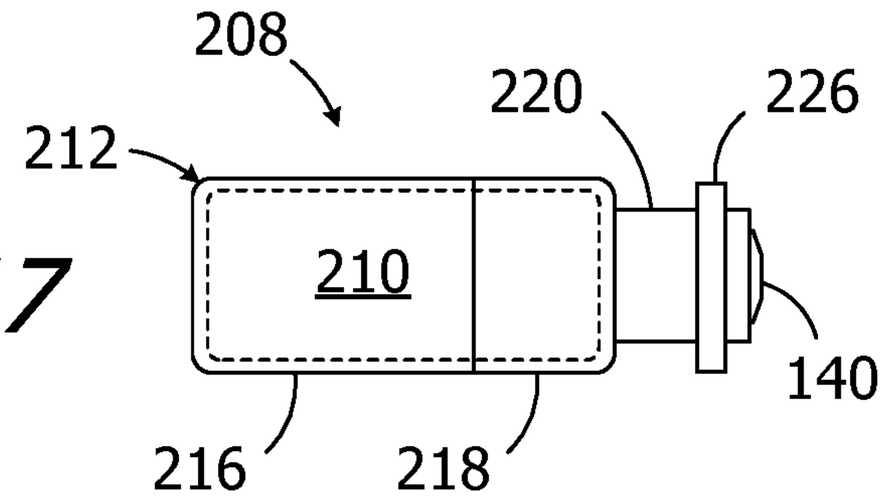


FIG. 17

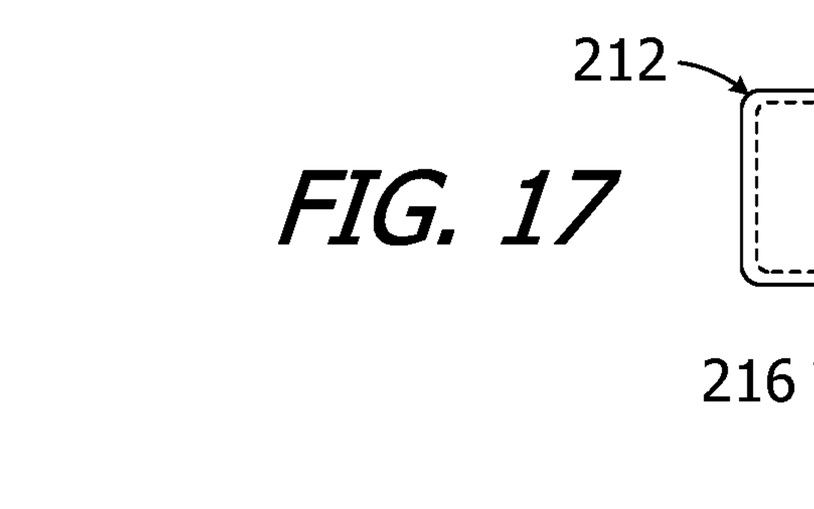


FIG. 18

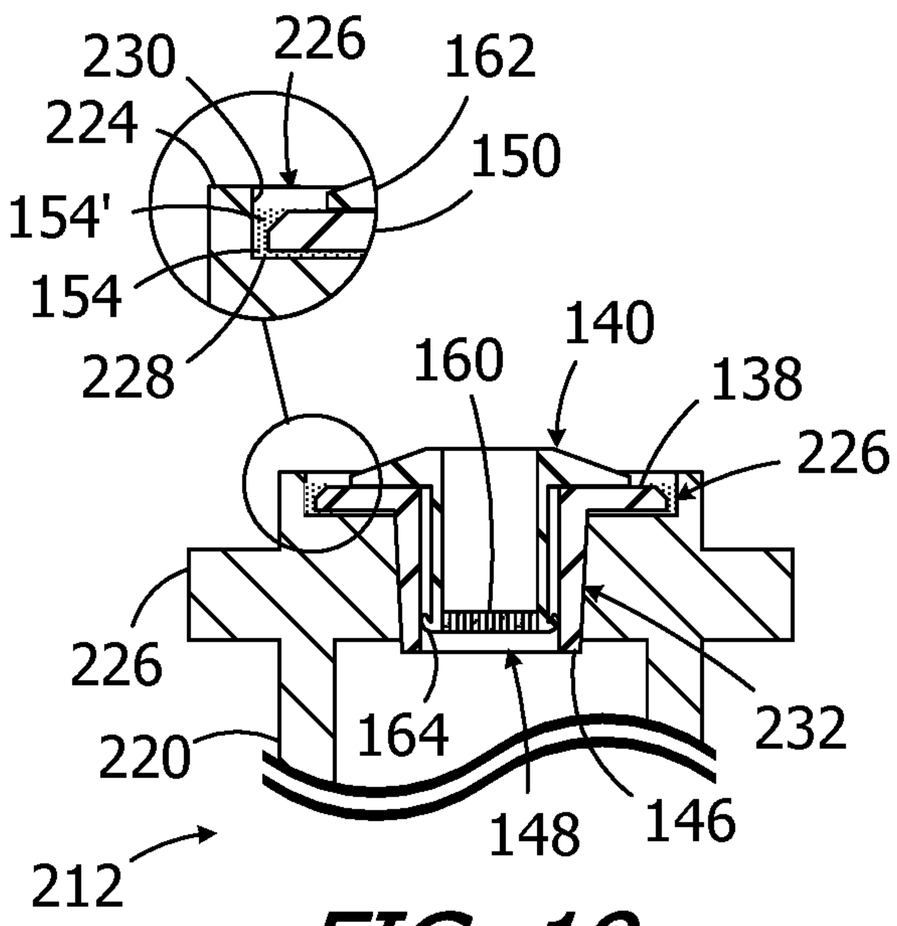


FIG. 19

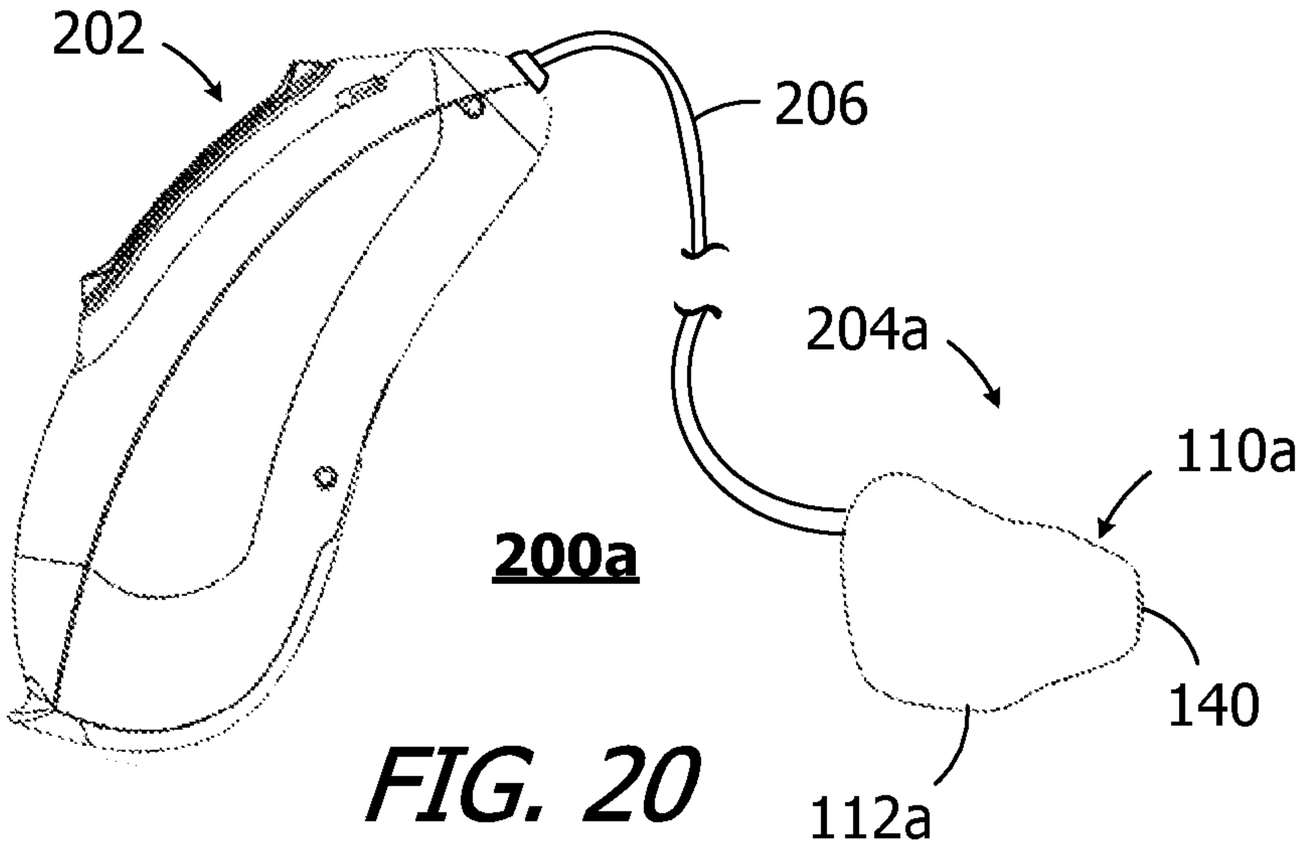
202
206
204a
110a
200a
140
112a

FIG. 20

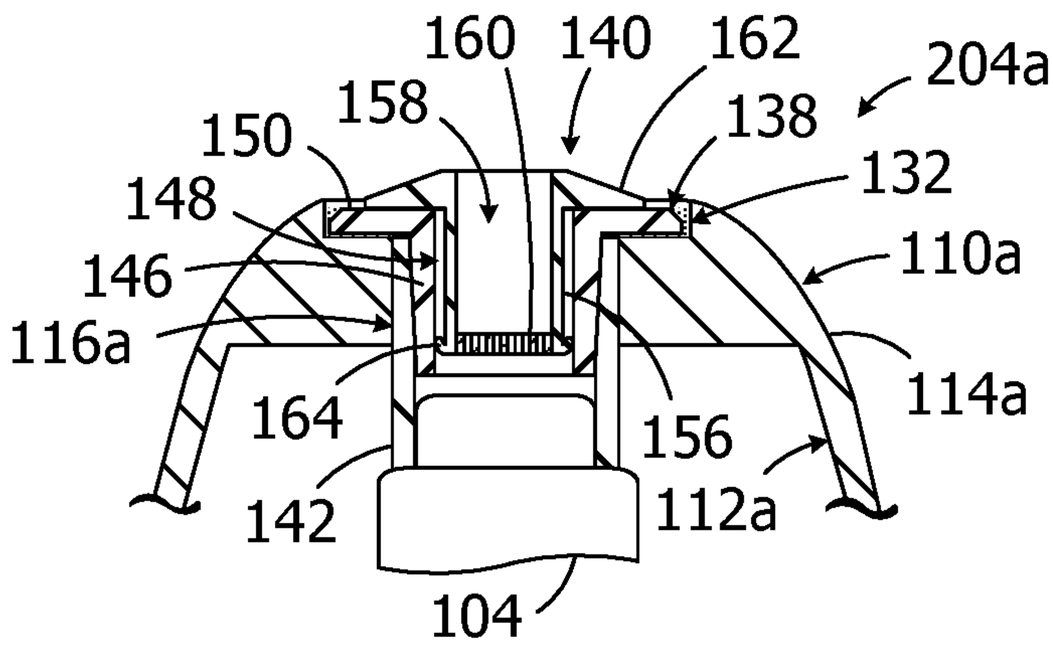
160
140
162
204a
158
138
150
132
148
110a
146
116a
114a
164
156
142
112a
104

FIG. 21

# HEARING DEVICE WITH WAX GUARD INTERFACE

## BACKGROUND

### 1. Field

The present inventions relate generally to hearing devices and, for example, hearing devices that are worn in the ear canal or that include a component that is worn in the ear canal.

### 2. Description of the Related Art

Many hearing devices (or portions thereof) are located within the ear canal. In-the-ear ("ITE") hearing device, for example, typically include a housing that is positioned within the ear canal and a receiver that located within the housing. The housing has a sound output port that is positioned adjacent to the tympanic membrane and connected to the receiver output port. Other hearing device components (e.g., the microphone, electronics and battery) may, for example, be located with the housing or within a faceplate mounted onto the end of the housing opposite the sound port. Behind-the-ear ("BTE") hearing devices, on the other hand, typically include a BTE component, with the microphone, electronics, and battery, and an ITE component that delivers sound to ear canal. The ITE component may include a receiver assembly, with a receiver and a receiver housing, and a soft earpiece that is mounted on the medial end of the receiver assembly to center the receiver relative to the ear canal with the sound output port of the receiver housing facing the tympanic membrane.

One issue associated with ITE hearing devices and the ITE components of BTE hearings devices is the risk of cerumen, which is commonly referred to as ear wax, clogging the sound output port within the ear canal. One proposed solution is to mount a replaceable wax guard over the sound output port. A plastic bushing is secured to the hearing device housing at the sound output port with an adhesive, and the wax guard is mounted to the bushing and over the sound output port. The plastic bushing includes a tube and a flange, with a top surface and a bottom (or "abutment") surface, that extends outwardly from the tube. In the conventional arrangement, the abutment surface of the bushing flange is secured to the outermost surface of the exterior of the hearing device housing with adhesive. The bushing is intended to be a permanent part of the associated hearing device (i.e., a part that is not removable under normal operation), while the wax guard is intended to be a removable and replaceable part of the associated hearing device.

Although conventional bushing and wax guard arrangements have proven useful, the present inventor has determined that they are susceptible to improvement. For example, the present inventor has determined that the conventional method of securing the plastic bushing to the hearing device housing results in an unacceptably high rate of the bushing/housing separations. The separation issue is especially acute in those instances where the plastic bushing is secured to a titanium housing for at least two reasons. First, the adhesive bond between titanium and plastic weakens over time. Second, positioning the bushing flange on the outermost exterior surface of the hearing device housing exposes the bushing flange to forces that can dislodge the bushing, e.g., the force associated with a fingernail wedging between the bushing flange and the exterior surface of the hearing device housing during a cleaning procedure.



## SUMMARY

An apparatus in accordance with one embodiment of a present invention has a hearing device housing including at least one wall with a sound aperture and a counterbore around the sound aperture, and a bushing, having a portion thereof located within the counterbore and secured thereto, configured to receive a hearing device cerumen guard. The present inventions also include hearing devices with such an apparatus.

There are a number of advantages associated with such a hearing devices and systems. By way of example, but not limitation, placement of the bushing within the counterbore reduces the likelihood that a fingernail or other object can wedge itself between the bushing flange and the housing or that a lateral force can be applied to the bushing flange. As such, even in those instances where adhesive or other instrumentality that secures the bushing to the housing is in a weakened state, the bushing is less likely to be dislodged from the hearing device housing.

The many features of the present inventions will become apparent as the inventions become better understood by reference to the following detailed description when considered in conjunction with the accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

Detailed descriptions of the exemplary embodiments will be made with reference to the accompanying drawings.

FIG. **1** is a perspective view of a hearing device in accordance with one embodiment of a present invention.

FIG. **2** is another perspective view of the hearing device illustrated in FIG. **1**.

FIG. **3** is an end view of the hearing device illustrated in FIG. **1**.

FIG. **4** is a perspective view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **5** is block diagram of the hearing device illustrated in FIG. **1**.

FIG. **6** is a partial section view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **7** is a plan view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **8** is a section view taken along line **8-8** in FIG. **7**.

FIG. **9** is a partial section view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **10** is a partial section view of a portion of the hearing device illustrated in FIG. **1** with additional adhesive.

FIG. **10**A is a partial section view of a portion of the hearing device illustrated in FIG. **1** with additional adhesive.

FIG. **11** is a side, cutaway view of a wax guard.

FIG. **12** is an end view of the wax guard illustrated in FIG. **11**.

FIG. **13** is another end view of the wax guard illustrated in FIG. **11**.

FIG. **14** is an exploded partial section view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **15** is a partial section view of a portion of the hearing device illustrated in FIG. **1**.

FIG. **16** is a side view of a hearing device in accordance with one embodiment of a present invention.

FIG. **17** is a side view of a portion of the hearing device illustrated in FIG. **16**.

FIG. **18** is a section view of a portion of the hearing device illustrated in FIG. **16**.

FIG. **19** is a section view of a portion of the hearing device illustrated in FIG. **16**.

FIG. **20** is a side view of a hearing device in accordance with one embodiment of a present invention.

FIG. **21** is a section view of a portion of the hearing device illustrated in FIG. **20**.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The following is a detailed description of the best presently known modes of carrying out the inventions. This description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the inventions.

As illustrated in FIGS. **1-5**, an exemplary in-the-ear (ITE) hearing device **100** includes a microphone **102**, a receiver **104**, a battery or other power supply **106**, and sound processing electronics **108** that are located within a housing **110**. The exemplary housing **110**, which is sized and shaped for positioning within the ear canal, includes a wall **112** with an outermost surface **114**, a sound output aperture **116** that defined by a side surface **118** as well as a venting aperture **120**, a venting aperture **122**, a handle aperture **124** for a removable handle (not shown). The shape of the housing **110** may be a generic shape that is suitable for a large number of patients or may be a custom shape that is 3D printed or otherwise formed for the ear canal of a particular patient. Suitable housing materials include, but are not limited to, plastics such as an acrylic and metals such as titanium. The exemplary hearing deice **100** also includes a housing cover **126** at the lateral end of the housing **110**. The battery **106** may be stored at or within housing cover **126** and, to that end, the exemplary housing cover includes a pivotable battery door **128**. A push button **130**, which may perform various function, may also be provided.

Referring more specifically to FIG. **4**, the exemplary housing wall **112** includes a counterbore **132** located around the sound output aperture **116**. The counterbore **132**, which is discussed in greater detail below with reference to FIGS. **6-10**, includes an abutment surface **134** and a side surface **136** that extends from the abutment surface to the outermost surface **114** of the housing wall **112**. The exemplary ITE hearing device **100** also includes a bushing **138** that is positioned within the counterbore **132** and permanently secured to the housing **110**, as well as a wax guard **140** that may be removably mounted to the bushing. As used herein, a bushing is permanently secured (or "connected") to a housing when, once connected, the bushing will remain on the housing under normal use conditions, and cannot be removed from the housing without destruction of the bushing, the housing and/or the adhesive bond (or other instrumentality) connecting the two. It should also be noted here that, in those instances where a titanium housing is formed using a 3D printing process, the surfaces of the counterbore **132** may require post-printing machining to smooth out any rough surfaces.

As illustrated for example in FIG. **6**, a sound tube **142** may be used to direct sound from the receiver **104** to the sound output aperture **116** of the housing **110**. In the illustrated implementation, the sound tube **142** is mounted on the receiver output port **144** and may be secured to the housing **110** and, in particular, may be secured to the side surface **118** that defines the sound aperture **116**, with adhesive (not shown) or some other suitable instrumentality (not shown). Should any of the sound tube **142** extend into the counterbore **132** after the sound tube is secured to the housing **110**, that portion of the sound may be removed so that the end of the sound tube is flush with the counterbore abutment surface **134**.

Turning to FIGS. **7** and **8**, the exemplary bushing **138** includes a tube **146**, with a lumen **148**, and a flange **150** that extends radially outwardly from the tube. The bushing **138** is also configured to fit within the counterbore **132**. As such, the flange outer diameter $D_F$ may be either less than (as shown) or equal to counterbore diameter $D_C$ (FIG. **6**). The flange thickness $T_F$ may be either less than (as shown), equal to or slightly greater than the counterbore thickness $T_C$ (FIG. **6**).

The bushing **138** may be permanently secured to the housing **110** and, more specifically, may be permanently secured to the housing wall **112** at the medial end of the housing and within the counterbore **132** in the exemplary manner illustrated in FIG. **9**. The bushing lumen **148** is within the sound tube lumen **152**, thereby enabling the wax filter **140** to be aligned with the sound tube **142** when the wax filter is mounted to the housing **110** in the manner discussed below with reference to FIGS. **14** and **15**. An adhesive **154** is deposited onto the counterbore abutment surface **134** and the bushing flange **150** is placed onto the adhesive, thereby permanently connecting the bushing **138** to the housing **110**. The bushing tube **146** extends into the sound tube lumen **152**. Suitable adhesives include, but are not limited to, a biocompatible UV curing adhesive, a biocompatible instant adhesive, or any suitable glue. Additionally, in those instances where the flange outer diameter DF is less than the counterbore diameter Dc (as in the illustrated embodiment), a small gap may remain between the outer perimeter of the bushing flange **150** counterbore side surface **136**. This gap may be filled with additional adhesive **154'**, as shown in FIG. **10**. Turning to FIG. **10**A, additional adhesive **154"** may also be deposited onto the top of the bushing flange **150** and a portion of the housing wall outermost surface **114**. The additional adhesive **154'** and **154"** may be the same as, or different than, the adhesive **154**. The additional adhesive **154'** and **154"** may also be Loctite **4310** or a suitable biocompatible coating.

Referring to FIGS. **11-13**, and although the present inventions are not limited to use with any particular wax guards, the exemplary wax guard **140** includes a tube **156** with an internal lumen **158**. The tube **156** is open at one end, while a wax filter **160**, which prevents cerumen from passing through the lumen **158**, is located at the other end. The wax guard **140** also include a flange **162** at the open end of the tube **156** and a small projection **164** at the end of the tube with the wax filter **160**. The wax guard **140** may be secured to the housing **110** by way of the bushing **138** in, for example, the manner illustrated in FIGS. **14** and **15**. After being positioned adjacent to the bushing **138**, with the wax guard tube **156** aligned with the bushing lumen **148**, the wax guard **140** may be pushed into the bushing lumen. The outer diameter of the wax guard projection **164** is slightly greater than the diameter of the bushing lumen **148**. As a result, the wax guard projection **164** will deflect and/or a portion of the bushing tube **146** will be indented when the wax guard projection enters the bushing lumen **148**. This creates an interference fit that secures the wax guard **140** to the housing **110** during use, yet allows the wax guard to be removed and replaced as necessary.

There are a variety of advantages associated with the present configuration. By way of example, placement of the bushing **138** with the counterbore **132** results in the bushing/

housing interface being below the outermost surface **114** of the associated housing wall **112** (or otherwise offset from the outermost surface depending upon the orientation of the hearing device). Such positioning reduces the likelihood that an object, such as a fingernail or a cleaning cloth, moving along the outermost surface **114** of the housing wall **112** will wedge itself under, or simply apply a lateral force to the bushing flange **150**. This, in turn, reduces the likelihood that the bushing **138** will be dislodged from the hearing device housing **110**. The likelihood of dislodging is further reduced through the use of adhesive **154'** around the perimeter of the bushing flange **150** and/or the adhesive **154"** over the top surface of the bushing flange.

Another exemplary hearing device is generally represented by reference numeral **200** in FIG. **16**. The exemplary hearing device **200** includes a behind-the-ear (BTE) component **202**, with one or more microphones, a sound processor, a power source and other conventional instrumentalities, and an in-the-ear (ITE) component **204** that delivers sound to ear canal. A cable **206** electrically connects the BTE component **202** to the ITE component **204**. The exemplary ITE component **204** includes a receiver assembly **208**, with a receiver **210** and a receiver housing **212**, and a soft earpiece **214** that is mounted on the medial end of the receiver assembly **208** to center the receiver relative to the ear canal. Referring also to FIGS. **17** and **18**, the receiver housing **212** has base **216**, a cover **218**, a tubular wall **220** that defines a sound tube with a sound output aperture **222** and a medial end **224**, and an earpiece connector **226** that projects outwardly from the tubular wall.

A bushing **138** for the wax guard **140** may be secured to the medial end of the receiver housing **212** and, in particular, at the medial end **224** of the tubular wall **220**. To that end, and referring to FIGS. **18** and **19**, the medial end **224** of the tubular wall **220** includes a counterbore **226** located around the sound output aperture **222**. The counterbore **226** includes an abutment surface **228** and a side surface **230** that extends from the abutment surface to the medial end **224**. The bushing flange **150** may be located within the counterbore **226**, while the bushing tube **146** may be located within the sound output aperture **222**. As is described in greater detail above in the context of the counterbore **132**, the respective sizes of the bushing **138** and the counterbore **226** may be such that the thickness of the bushing flange **150** is less than (as shown), equal to or slightly greater than the counterbore thickness. Adhesive **154** between the counterbore abutment surface **230** and the bushing flange **150** permanently connects the bushing **138** to the housing **212**. Additionally, as the flange outer diameter is less than the counterbore diameter in the illustrated implementation, the small remaining gap may be filled with additional adhesive **154'**. Adhesive may also be provided in the manner illustrated in FIG. **10**A.

The wax guard **140** may be secured to the housing by way of the bushing **138** in, for example, the manner illustrated in FIG. **19**. Here too, the wax guard **140** may be pushed into the bushing lumen **148**. The outer diameter of the wax guard projection **164** is slightly greater than the inner diameter of the bushing lumen **148**. As a result, the wax guard projection **164** will create an interference fit that secures the wax guard **140** to the bushing tubular wall **146** during use, yet allows the wax guard to be removed and replaced as necessary.

Another exemplary hearing device is generally represented by reference numeral **200***a* in FIGS. **20** and **21**. Hearing device **200***a* is substantially similar to hearing device **200** and similar elements are represented by similar reference numerals. For example, the exemplary hearing device **200***a* includes a behind-the-ear (BTE) component **202**, with one or more microphones, a sound processor, a power source and other conventional instrumentalities, and an in-the-ear (ITE) component **204***a* that delivers sound to ear canal. A cable **206** electrically connects the BTE component **202** to the ITE component **204***a*. Here, however, the ITE component **204***a* does not include a soft earpiece **214** and instead includes a relatively rigid receiver housing **110***a* in which a receiver **104** is located. The receiver housing **110***a*, which may be formed from materials such as acrylic or titanium, is sized and shaped for positioning within the ear canal, and includes a wall **112***a* with an outermost surface **114***a*, a sound output aperture **116***a*. The ITE component **204***a* also includes the above-described counterbore **132** and bushing **138** secured thereto, A wax guard **140** may be secured to the housing **110***a* by way of the bushing **138** in, for example, the manner illustrated in FIG. **21** and described in detail above with reference to FIGS. **14** and **15**.

Although the inventions disclosed herein have been described in terms of the preferred embodiments above, numerous modifications and/or additions to the above-described preferred embodiments would be readily apparent to one skilled in the art. The inventions include any combination of the elements from the various species and embodiments disclosed in the specification that are not already described. It is intended that the scope of the present inventions extend to all such modifications and/or additions and that the scope of the present inventions is limited solely by the claims set forth below.

We claim:

**1**. An apparatus, comprising:

a hearing device housing including at least one wall with an outer surface, a sound aperture and a counterbore around the sound aperture, the counterbore defining an abutment surface and a side surface defining an inner diameter and extending from the abutment surface to an end at the wall outer surface;

a bushing, including a tube and a flange extending outwardly from the tube that defines an outer perimeter and an outer diameter that is less than the counterbore side surface inner diameter, an abutment surface, and a top surface, configured to receive a hearing device cerumen guard, the flange being located within the counterbore and the flange abutment surface being secured to the counterbore abutment surface with adhesive located between the flange abutment surface and the counterbore abutment surface; and

adhesive around the outer perimeter of the bushing flange at the counterbore side surface end.

**2**. An apparatus as claimed in claim **1**, further comprising:

adhesive coating the bushing flange top surface.

**3**. An apparatus as claimed in claim **1**, further comprising:

a cerumen guard mounted to the bushing.

**4**. An apparatus as claimed in claim **1**, wherein

the at least one wall comprises a titanium wall.

**5**. An apparatus as claimed as claimed in claim **1**, wherein

the hearing device housing comprises an in-the-ear hearing device housing.

**6**. An apparatus as claimed in claim **1**, wherein

the hearing device housing comprises a hearing device receiver housing.

**7**. A hearing device, comprising:

an apparatus as claimed in claim **5**; and

a receiver within the in-the-ear hearing device housing and including a sound outlet operably connected to the housing sound aperture; and

a microphone operably connected to the receiver.

8. A hearing device, comprising:

a microphone and a battery within a behind-the-ear hearing device housing;

an apparatus as claimed in claim 6; and

a receiver within the hearing device receiver housing, the receiver being operably connected to the microphone and including a sound outlet operably connected to the housing sound aperture.

9. An apparatus, comprising:

a hearing device housing including at least one titanium wall with an outer surface, a sound aperture and a counterbore around the sound aperture, the counterbore defining an abutment surface and a side surface defining an inner diameter and extending from the abutment surface to an end at the wall outer surface; and

a bushing, including a tube and a flange extending outwardly from the tube that defines an outer perimeter and an outer diameter that is less than the counterbore side surface inner diameter, an abutment surface, and a top surface, configured to receive a hearing device cerumen guard, the flange being located within the counterbore and the flange abutment surface being secured to the counterbore abutment surface with adhesive located between the flange abutment surface and the counterbore abutment surface.

10. An apparatus as claimed in claim 9, further comprising: a cerumen guard mounted to the bushing.

11. An apparatus as claimed in claim 9, wherein the hearing device housing comprises an in-the-ear hearing device housing.

12. An apparatus as claimed in claim 9, wherein the hearing device housing comprises a hearing device receiver housing.

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